SYNOPSIS

TITLE :- MECHANICAL AND MOISTURE ABSORPTION PROPERTIES OF FIBER REINFORCED POLYMER**.**

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1. INTRODUCTION

Polymer matrix composite materials are used in many industrial applications including commercial, military, aerospace, naval, automotive, etc. Several PMCs offer marine applications significant advantages, and much focus has been placed on carbon fiber and glass fiber reinforced in vinylester resin composites. Fiber-reinforced composites are materials that consist of high strength and high modulus fibers embedded in and bonded to a matrix with a defined interface between the fiber and matrix. Fiber-reinforced composite materials are able to be manufactured with a controlled orientation of the reinforcing fibers to achieve a material with design qualities such as high stiffness and strength, and durability. The high strength and high modulus to weight ratio properties of composite materials provide structural parts. The high corrosion resistance of composite materials translates into less overall maintenance and repair cost than for metallic materials. However, fiber-reinforced composites with a polymer matrix are affected by several environmental factors such as elevated temperatures, ultraviolet rays, corrosive fluids, and immersion in seawater. Such degradation must be understood and considered for in design of composite structures. Even if a lot of studies have been performed suitable tools to predict long term behaviour in marine conditions need to be developed and provided to the design engineer. Stress corrosion cracking mechanism is the unexpected and sudden failure of composite materials subjected to a stress in a corrosive environment. Prevention of these failures requires proper selection of fibre and resin, and may require protective layer coatings.

Gel coat have used in many sector start from household equipment to military submarine. Gel coat are widely used to provide exterior protection for the finished part of fiber reinforced composite material. However, as coatings can be vulnerable to corrosion and/or erosion in harsh

marine environments, they may gradually lose their protective abilities, leading to damage accumulation in the protected composites. The degradation in composite laminates is probed through measuring the flexural strength. There are many factors need to be considered if wanted to produce a good surface and long service period product. It is a primary focus to achieve proper gel coat film thickness because it is a critical control point for crack prevention which is able to increase mechanical strength and withstand harsh environment. There are no specific standards to verify that how much gel-coat thickness required to produce certain product since mostly research were focused on the enhancement of mechanical properties by changing orientation and fiber combination **[12]**.

1.1 The salt spray (or salt fog) test

The salt spray (or salt fog) test is a standardized and popular corrosion test method, used to check corrosion resistance of materials and surface coatings. Usually, the materials to be tested are metallic (although stone, ceramics, and polymers may also be tested) and finished with a surface coating which is intended to provide a degree of corrosion protection to the underlying metal. Salt spray testing is an accelerated corrosion test that produces a corrosive attack to coated samples in order to evaluate (mostly comparatively) the suitability of the coating for use as a protective finish. The appearance of corrosion products (rust or other oxides) is evaluated after a pre-determined period of time. Test duration depends on the corrosion resistance of the coating; generally, the more corrosion resistant the coating is the longer the period of testing before the appearance of corrosion/ rust. The salt spray test is one of the most widespread and long established corrosion tests **[11]**.

2.0 LITERATURE REVIEW

Literature survey is carried out to get the background of information related to the mechanical and moisture properties of polymer matrix composites.

V. Fiore et. al. [1] aims to investigate the effect of salt-fog exposition on the mechanical behavior of composite/metal riveted joints. Two kinds of joint were exposed to salt-fog environmental conditions according to ASTM B117 standard, for fifteen weeks. In particular, two composite laminates (i.e. glass fibre and carbon fibre/epoxy composites) were used as composite substrate joined with the metal substrate (i.e. aluminum alloy Al 6060). Single-lap shear tests were carried out in order to evaluate the evolution of the mechanical performances and the damage mechanisms of the riveted joints during the ageing exposition. The results reveal that the mechanical performances (i.e. maximum load and load-displacement slope) of the hybrid joints progressively decrease at increasing ageing time exposure. Moreover, glass fibre/epoxy hybrid composite joint showed a higher sensitivity to degradation in salt-fog environmental condition than carbon fibre/ epoxy one. As concerns the damage mechanisms, glass fibre/epoxy hybrid composite joint experienced catastrophic cleavage/net tension failure modes regardless of the ageing exposure time. In contrast, the progressive bearing failure mechanism was observed in carbon fibre/epoxy hybrid composite joint during the entire experimental campaign. Corrosion phenomena not significantly affected degradation performances of both joints.

A. Boisseau et. al.[2] presented the fatigue behavior of composite materials reinforced with different types of glass fibre is characterized in air and in sea water; the influence of testing in sea water rather than air is shown to be small. Tests were performed in four point flexure on dog bone specimens. In order to understand the different phenomena involved in the fatigue in sea

water, cyclic tests have also been performed on aged specimens. These specimens were aged in natural circulating sea water at 60°C with periodic weighing to check their water uptake, diffusion kinetics. The result showed that saturation was reached after 15 weeks of exposure time. However, sea water ageing is shown to reduce the fatigue life significantly and this strongly depends on matrix formulation.

Boisseau Amélie et. al. [3] quantified the influence of glass fiber type (E-glass epoxy, adv/epoxy, hp/epoxy) as a function of the environment by performing static tests (Flexural test , tensile and compression) both in air and in natural circulating sea water. The pre and post ageing mechanical properties were determined for different exposure time. It was noticed that the water absorption of composite specimens is a function of water absorption of matrix material and its interface. So it is important to understand the kinetic of diffusion in the matrix. For this reason the natural sea water ageing was also performed on pure resin specimen infused using same process parameter and cure cycle. The experimental results were validated by numerical modeling to simulate the coupling between water absorption and mechanical behavior

Khouloud Cheour et. al. [4] presentated the water uptake behaviour of flax fibre reinforced epoxy SR 1500 resin associated with SD 2503 hardener. The flax fibres fabrics used are quasi-unidirectional. The composite laminates were fabricated by press platen process and subjected to water immersion at room temperature. Mechanical and damping properties of un-aged and aged materials were investigated using free vibrations. Further the specimens were dried and tested to study the reversibility of the variation of those properties caused by water ageing. The results showed that water uptake induces a decrease in the bending modulus and an increase in loss factors compared in term of ageing time. It was also presented that the variations are practically reversible in the case of loss factors but irreversible in the case of bending modulus.

N. Venkateshwaran et. al. [5] performed tensile, flexural, impact and water absorption tests using banana/epoxy composite material. Initially, optimum fiber length and weight percentage were determined. To improve the mechanical properties, banana fiber was hybridized with sisal fiber. This study showed that addition of sisal fiber in banana/epoxy composites up to 50% by weight results in increasing the mechanical properties and decreasing the moisture absorption property. Morphological analysis was carried out to observe fracture behaviour and fiber pull-out of the samples using scanning electron microscope (SEM).

Hassan Izadi Gonabadi et. al. [6] investigated the fatigue behaviour of sandwich composites (PVC foam was used as a core material and chopped strand mat (CSM) glass in the matrix of polyester resin was used in the face of sheet metal) when exposed to air and seawater. S– N curves were obtained for different stress levels. 3-point bending (3PB) tests were also performed to investigate strength degradation during the fatigue test. Finite element analyses were carried out to determine the stress distribution in the test coupons used in bending tests. There is good agreement between finite element analysis and experimental results at lower loads. Small deviations were observed at higher loads due to the influence of defects. The results of 3 point bend test show that decreasing the thickness of the core and the number of layers will result in better mechanical properties. The typical failure modes observed under quasi-static 3 point bend test were due to debonding, fibre pull-out and matrix cracking.

Afshar et. al. [7] performed study on environmental based degradation of composite structures with protective coatings. The carbon vinylester composite laminate was coated with gelcoat of isophthalic-neopentyl glycol (ISO/NPG) polyester resin. However, as coatings can be vulnerable to corrosion and/or erosion in harsh marine environments, they may gradually lose their protective abilities, leading to damage accumulation in the protected composites. To demonstrate

the criticality of this process, gel-coated carbon fiber-vinyl ester laminates are subjected to a simulated marine environment consisting of ultraviolet (UV) radiation, moisture, and cyclic mechanical loading. Degradation in composite laminates is probed through measuring the flexural strength. Damage in gelcoat is further characterized by digital microscopy for its surface. Correlation between degradation of the gelcoat surface and loss in the mechanical properties of coated composite laminates is also investigated.

Madhusudhan.S.V et. al. [8] presented the effect of coconut shell powder filler on the fatigue behavior of glass fiber reinforced polymer composite. The tensile and fatigue tests have been carried out for 4 mm and 10 mm length glass fibers, vinyl ester and coconut shell powder filler composites with varied volume fraction. The results show that the composite made with 10 mm length glass fiber gave good tensile and low cycle fatigue strength when compared to composite made with 4 mm length glass fiber by considering the different composition with or without coconut shell powder used as filler. The addition of filler content improves the fatigue life of a composite material.

P. K. Mallick et. al. [9] examined the static and fatigue properties of high glass content sheet moulding compound (SMC) material at various temperature. It was shown that the matrix plays an important role in both fatigue characteristics and failure mechanisms of such randomly oriented short fiber composite. The material used in this study is polyester (isophthalic) and vinyl ester HMSC with nominal glass fiber content 60-65% by weight. The study was also carried out on epoxy material. Fatigue test were performed on an modern servo hydraulic machine with three point constrained flexure fixture. In random fibre composite matrix play an important role in determining the fatigue characteristics of material. Vinylester matrix shows better fatigue properties compared to polyester and equivalent properties to that of epoxy matrix. Fatigue

damages in these materials are manifested by a cluster of micro crack, whose severity depends on the choice of matrix.

Hazizan Md Akil et. al. [10] investigated the environmental degradation and mechanical properties of pultruded jute and jute/glass hybrid reinforced polyester composites with high fibre volume fraction (70%). The research mainly focuses on the effects of water ageing at moderate temperature (up to 80 LC). Water absorption tests were conducted by immersing specimens in distilled water at room temperature until saturation (4076 h). Water absorption curves and characteristic parameters such as coefficient of diffusion and equilibrium moisture content were determined. The composites exhibited a deviation from the Fickian behaviour with a positive role played by the addition of glass fibres in terms of moisture resistance. The influence of water uptake on tensile and flexural properties of composites was evaluated and a significant reduction in both strength and modulus was observed, with a superior strength retention offered by hybrid composites. Acoustic emission (AE) and scanning electron microscopy enabled to identify the weakening of fibre/matrix interface induced by water ageing. The effects of temperature were mitigated by glass fibres if compared with the higher degradation experienced by jute fibres.

Amélie Boisseaua et. al. [11] studied the influence of specific environmental marine conditions on composite material behavior, especially in cyclic loading. In order to perform a comparative study of fatigue behavior, three composite materials have been tested and analyzed. Fatigue tests have been carried out in bending on composite materials at initial state and after sea water ageing. The fatigue life and the evolution of the damage have been compared for each material.

Yuhazri M.Y et. al. [12] reviewed the effect of gelcoat and its thickness on mechanical performance of composite materials. The fabrication process for gelcoat material, the physical

properties and performance of the gelcoat with composite structure also listed in this review. The detailed review shows that very less or almost no work is found related to gelcoat thickness.

3.0 LITERATURE GAP:

Based on the above literature review it was found that most of the research work was devoted to mechanical performance and moisture absorption characteristics of composite materials. It was found that a very least work is carried out on protective metal coatings applied to composite materials and their performance in terms of mechanical and moisture characteristics. In addition coating thickness plays a very important role in mechanical and moisture behaviour of composites and which is not studied in line with other investigations. For composite structures used in marine applications is a big challenge because of severe environment conditions: salt concentration, high hygrometry, UV exposition. Hence, the present work focuses to investigate the mechanical performance and water absorption characteristics of Fiber Reinforced Polymer (FRP) composite with proper surface coatings and optimization of coating thickness for improving mechanical and moisture resistance behaviour.

4.0 OBJECTIVES AND METHODOLOGY

4.1 Objectives

To fill up the literature gap, following objectives are set for the research work

- Development of Fiber Reinforced Polymer (FRP) composite structures based on specific end application.
- To develop FRP composite laminates with proper protective metal coatings.
- Experimental investigation of mechanical and moisture performance of developed laminates (i.e., with and without coating laminates)

- Optimization of coating thickness for improving the mechanical and moisture performance of developed laminates
- Experimental investigation of mechanical properties of optimized laminate.
- Investigation of moisture absorption behaviour of optimized laminates for varying exposure time and environmental conditions.
- Validation of experimental results using numerical/analytical/statistical techniques.

4.2 Methodology

In order to achieve the above mentioned objectives following methodology is followed**.**

- Exhaustive literature review based on relevance of the title.
- Selection of proper constituents of composite materials as well as coatings based on specific end applications and or by performing some pilot experiments.
- Development of with and without coating composite laminates of selected constituents.
- Testing of composite laminates for mechanical properties and moisture performance using ASTM standards.
- Validation of experimental results using numerical study or analytical study or by using some statistical techniques.

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